THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the REAPS Technical Symposium

Paper No. 5:
User Requirements for the Newport news Interactive Pipe Design System (RAPID)

		Form Approved
Report Documentation Page		*Form Approved* *OMB No. 0704-0188*

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1. REPORT DATE **JUN 1977**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **The National Shipbuilding Research Program: Proceedings of the REAPS Technical Symposium Paper No. 5: User Requirements for the Newport News Interactive Pipe Design System (RAPID)**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192, Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT **SAR**	18. NUMBER OF PAGES **15**	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**			

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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Proceedings of the

REAPS Technical Symposium

June 21-22, 1977

New Orleans, Louisiana

USER REQUIREMENTS FOR THE NEWPORT NEWS

INTERACTIVE PIPE DESIGN SYSTEM (RAPID)

Patrick J. Kelly

and

Patrick W. Rourke

Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

As Supervisor of Manufacturing Computer Systems in the Production Computer Systems Department, Mr. Kelly is responsible for numerical control, production and inventory control. He has a B.S. degree in Physics from the University of Dayton and is currently studying for an M.B.A.

Mr. Rourke is in the Engineering Technical Department where he designed Newport News' CAPDAMS system, a computer aided piping design and manufacturing system.

1. SCOPE

We are in the middle of the programming phase of a mini-computer based project for improved piping design called RAPID.

Because RAPID has been presented at a number of REAPS and other industry meetings, I presume most of you have been exposed to it. Therefore, I will begin with just a brief overview of the project here.

2. OVERVIEW OF RAPID

Purpose
The purpose of the RAPID project is to develop a low cost system for the capture and error checking of ship piping design in order to produce manufacturing documents for the piping shop.

Hardware
The system being developed is based around a mini-computer and several design stations. Figure 1 illustrates the hardware configuration. Each design station consists of a large digitizing table and a graphics display screen. In use, the designer will scheme pipe in the conventional manner, and then take his pipe scheme to the computer, either in the form of a composite or arrangement drawing.

Menus
The drawing is layed down on the digitizer table. A command menu is also placed on the tablet. Like most interactive graphics systems, RAPID software is driven by commands issued by touching the digitizer to appropriate menu boxes. Figure 2 is a typical RAPID menu. The user alternates between touching menu commands and points on the drawing to input the pipe geometry to the mini-computer. The resulting geometry is stored on a small data base within the mini-computer.

Error Checking
From this data base extensive error checking can be invoked, and single line and double line plots can be produced by an on-line plotter. Various
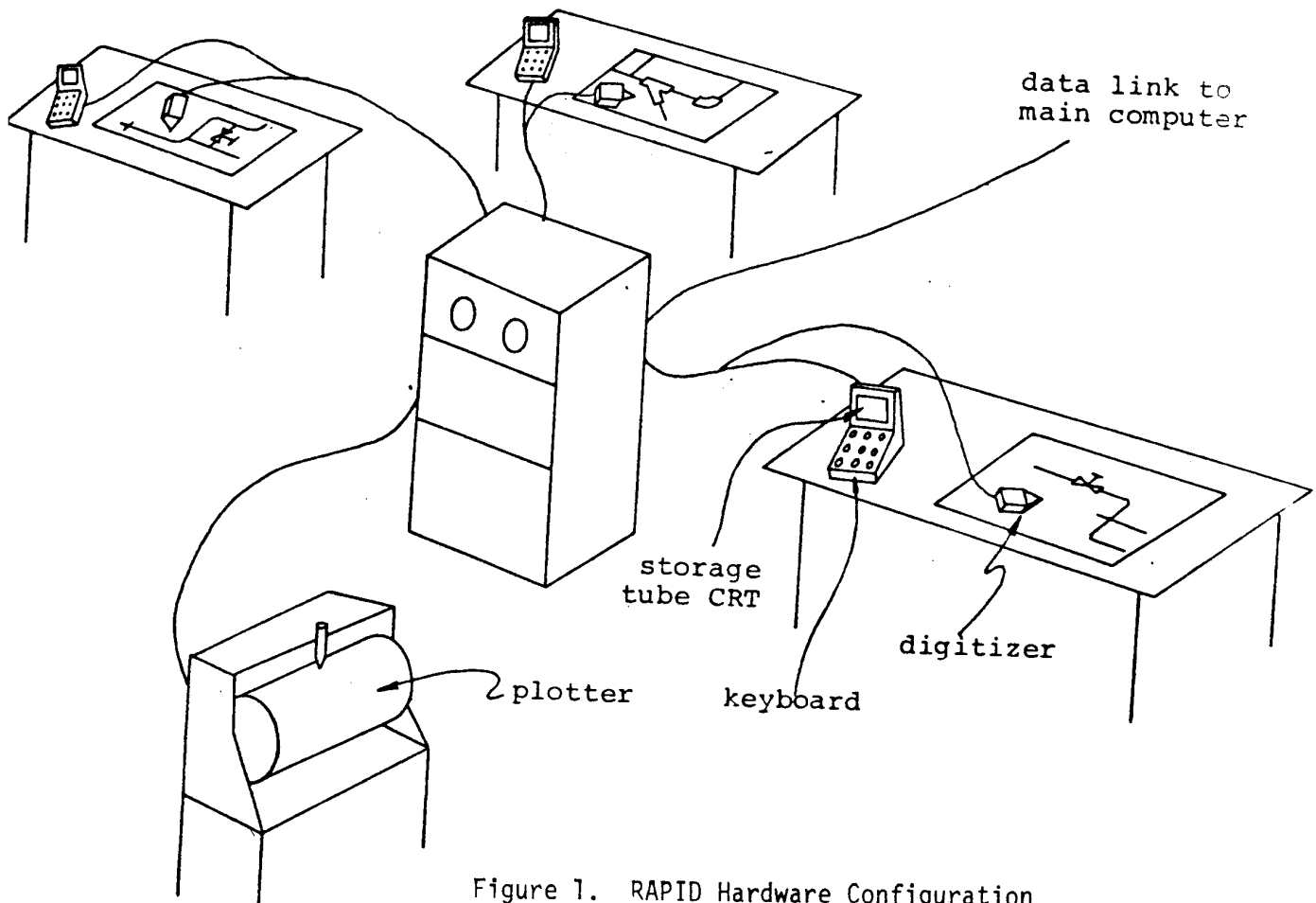
Figure 1. RAPID Hardware Configuration

Hardware	Vendor
Mini-computer 20 MByte disk 160 Kword memory TOTAL data management software	Varian V-76
Off-Line Storage Dual tape cartridge system	Kennedy
Plotter/Printer 22 inch wide	Varian
Digitizer 36 x 48 inch area Free Carsor	Samagraphics
Graphics Terminal Vector and character plotting Selective erase local zoom and pan	Hughes Aircraft

INPUT	START RUN	END RUN	PIPE	END	TURN
REVIEW			tee	elbow	coupling
OUTPUT					
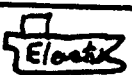
Nozzle	DIA
Old	RADIUS
	PN

check	apply schedule
geom.	SELECT
mfgr.	MODIFY

Msgs:

Stop	Scroll up	Scroll Down

1st Dk
2nd Dk
1st Plat
2nd Plat
Tank Top

YES		
NO	Prompt / No Prompt	SCROLL

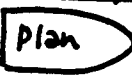| FT	W
SAME	

Plan	Section	Elevation	Put Screen	Copy View	ERASE LINE	BACKSPACE	RETURN

+	−	.	,	:	;	/	<	>	=	[	]	\	↑	?
				!	"	#	$	%	&	'	(	)	*	

1	2	3
4	5	6
7	8	9
*	0	#

A	B	C	D	E	F	G	H	I	J
K	L	M	N	O	P	Q	R	S	T
U	V	W	X	Y	Z	SPACE			

Figure 2. Typical Menu

design aids are being implemented, including automatic selection of fittings and some limited automatic correction of geometry errors.

Output

When the design has been completed, the user may request the production of pipe manufacturing instructions and material lists, and may have necessary data transferred by telephone to a main computer for interfacing to the yard's material control and production control systems and for more complex processing, such as production of weld joint maps. Figure 3 illustrates the communication between the various databases.

Status

This project is currently midway through development and is scheduled for delivery in March, 1978. At that time a demonstration workshop for interested individuals from the industry will be held at Newport News.

Summary

Input to RAPID allows users to:
- Define the geometry of pipe runs in a fast natural language
- Define decision rules for the selection of components
- Define the product structure (assemblies, subassemblies, etc.) associated with piping
- Define plots with arbitrary scales and viewing directions, and optional interactive labelling and dimensioning.

Processing allows users to:
- Apply decision rules to input pipe geometry and automatically select specific piping components as appropriate
- Check for design errors by testing pipe geometry against the known constraints of the pipe manufacturing facility
- Make modest changes in the pipe geometry to eliminate errors.

RAPID produces these items for user selected collections of piping:
- Piping drawings, with labels and dimensions of input
- Material lists
- Pipe bending instructions
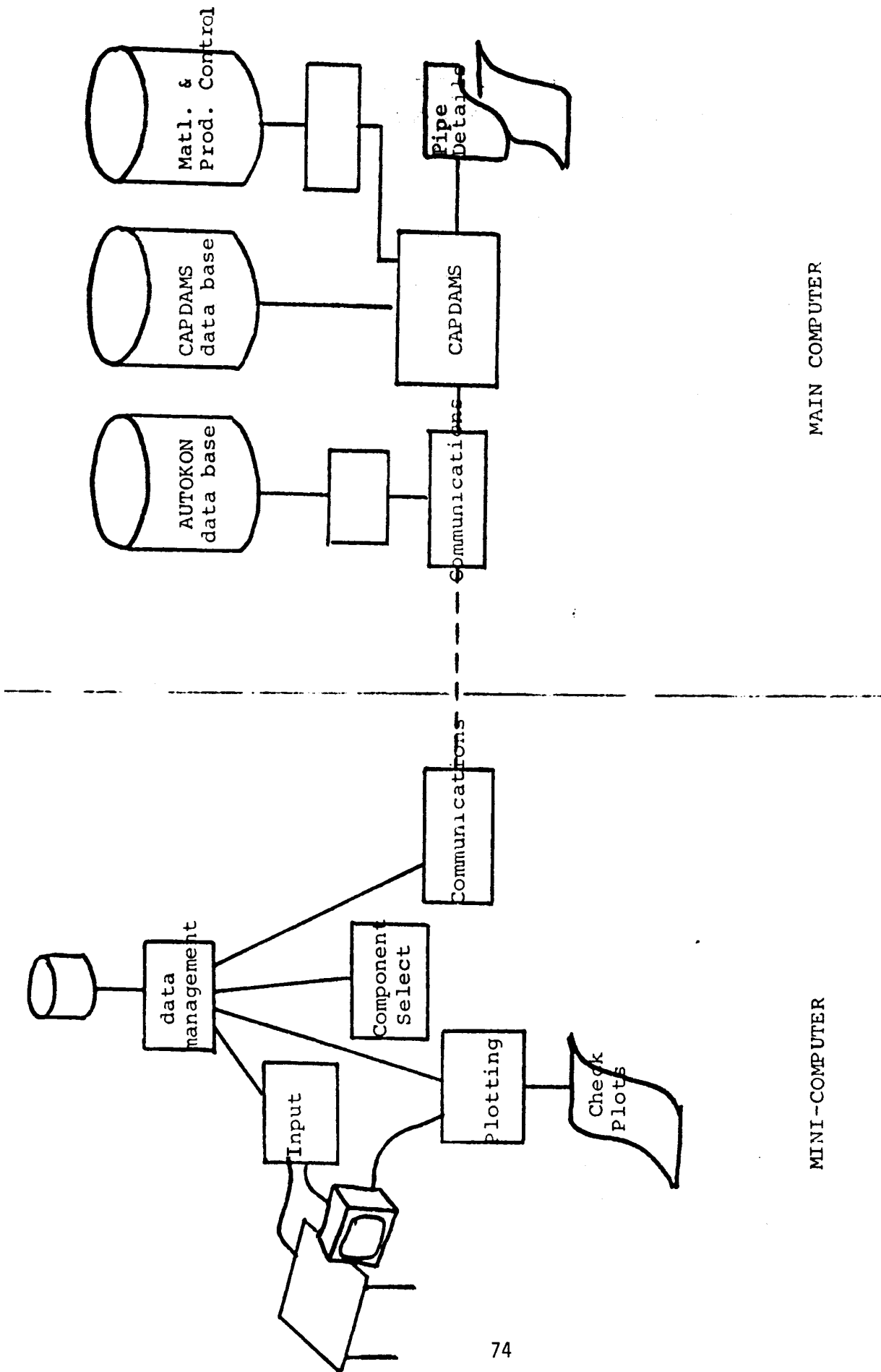- Schematic (joint map) drawings.

Figure 3. Database Interfaces

MAIN COMPUTER

MINI-COMPUTER

74

3. USER REQUIREMENTS

At this point I would like to cover the major user requirements that guided the design of the system. General requirements included software portability since this software should be readily usable by other yards on other computers at a relatively small conversion cost. A high degree of portability has been achieved by coding all programs in a subset of FORTRAN IV which includes non-ANSI standard features that are widely available or substitutable by subroutine calls. The language translator portion of the system has been converted from the Honeywell 6000 36-bit machine on which it was initially developed to the Varian V-76 16-bit machine in less than 20 man-hours. Conversion time of other modules is expected to be comparable.

The system also must be adaptable to other yard's requirements. Obvious programming techniques, such as variable field sizes, program modularity and segmentation are being used to make the software adaptable to other requirements with little extra effort. Some features (for example, the stand-alone production of pipe details) have been added to the design at the request of the User Review Group who felt certain features such as this one would make the system more quickly adaptable to other yard's environments.

Low cost is also an overriding concern and dictated the minicomputer hardware approach.

The ability to expand the software in the future overlaps somewhat with the other requirements. To readily expand from one to four stations, add modules and new programs, etc., are easy to accomplish since the system is modular and runs under a standard version of VARIAN's computer operating system.

The system also allows working with multiple piping systems at the same time by different designers at different stations without files becoming mixed up and without all files continuously on-line.

The efficiency with which the system handles changes and revisions is difficult to estimate since there are so many points where the designer can stop his work, make changes, call up other drawings, etc. The system is

flexible in allowing changes by the designer.

Approval and release controls mimic conventional drawing controls by using passwords, log-on identification sequences and recording of who made what change to the database and when it occurred.

4. OPTIONS

After identifying our requirements, the first thing we did was conduct a make/buy study. The options available were:

(a) Purchase a packaged hardware/software system from one of the vendors of interactive graphics systems and modify it or have it modified for our needs.

(b) Develop software from scratch, using a portable higher level language (such as FORTRAN) and a standardized data base manager, and implement a mini-computer.

(c) Develop a hybrid system consisting of a packaged graphics system, optimized for graphics speed, tied to a minicomputer of our choice running generalized data base software to meet our data base flexibility requirements. Hardware costs prohibited this alternative, however.

(d) Write programs in a high level language and implement them in a time-shared mode on large computers.

For most yards the last option is attractive because it requires minimal expenditures for new hardware. Unfortunately, the response requirements, especially with several design stations doing on-line plotting at the same time, can tie up a sizable portion of mainframe resources. The estimated time-sharing bill on our main-frame computer, for example, would have exceeded in six months the purchase price of a minicomputer capable of doing the job. Nevertheless, for users with light workloads, time-shared use of a main-frame may be the best solution, and the RAPID software to be delivered can be converted to operate in this manner.

We chose to go with a commercially available data management package, TOTAL, and develop our own interactive graphics software, rather than take a packaged interactive graphics system and modify its data base to meet our needs. Commercially available data management software is very good in terms of flexibility, reduction of programming effort, and backup and recovery control. Commercial data management software is also considerably slower than packaged graphics systems which use specialized data structures optimized for plotting.

Data Base Size

The total size of the piping data base for a design activity engaged in the design of several ships, including pipe and hull geometry and piping catalog information, is estimated at 200 million bytes. Although on-line disk storage is dropping substantially in price, this size is beyond the RAPID hardware cost, targeted at $100K.

We searched without success for a generalized data base management system which would be capable of selectively loading portions of the total data base. Not finding such software, we adopted a strategy which defines a master on-line data base, and stores data off-line in files. Data is selectively loaded into the on-line data base as needed. Most of the RAPID application programs operate on this master data base unaware of the fact that data originated from different files. A penalty is that it takes more time to load data onto the data base since it must be reformatted each time. We are expecting a two-minute format and load time for a typical piping drawing file, which we consider acceptable.

Response Time

The packaged graphics systems go to considerable lengths to design their data base software, and sometimes even hardware, for fast drawing of pictures. After some study, we set a limit of no more than 20 seconds to draw a typical piping view on a CRT screen. We knew that some package systems could beat this by a factor of eight, but we felt that 20 seconds was acceptable for the ship design environment.

A benchmark computer program was developed which tested the ability of a minicomputer and data base management software to retrieve data at a rate sufficient to meet the 20 second limit. Minicomputer vendors were asked to run this benchmark, and the final selection, a Varian V-76 with TOTAL data base software, was heavily influenced by the benchmark.

One of the original objectives of using a generalized data base manager had been to avoid redundant information storage. In order to meet the plotting response requirement, however, it was necessary to go to a partially redundant data structure in which separate records were kept just for plotting.

In a digitizer-based system the computer must be able to identify items as they are pointed out. This means that the computer must be able to search its data base on the basis of 3-D locations in space. Further, it is essential that the computer be able to respond rapidly, say within two seconds, to a digitizer touchdown.

Associative type data base software might meet this requirement, but this capability is beyond presently available standardized data base software. Our approach was to take an in-house developed bit-oriented 3-D indexing technique and implement it in FORTRAN as an outside index into the slower generalized data base, as illustrated in Figure 4.
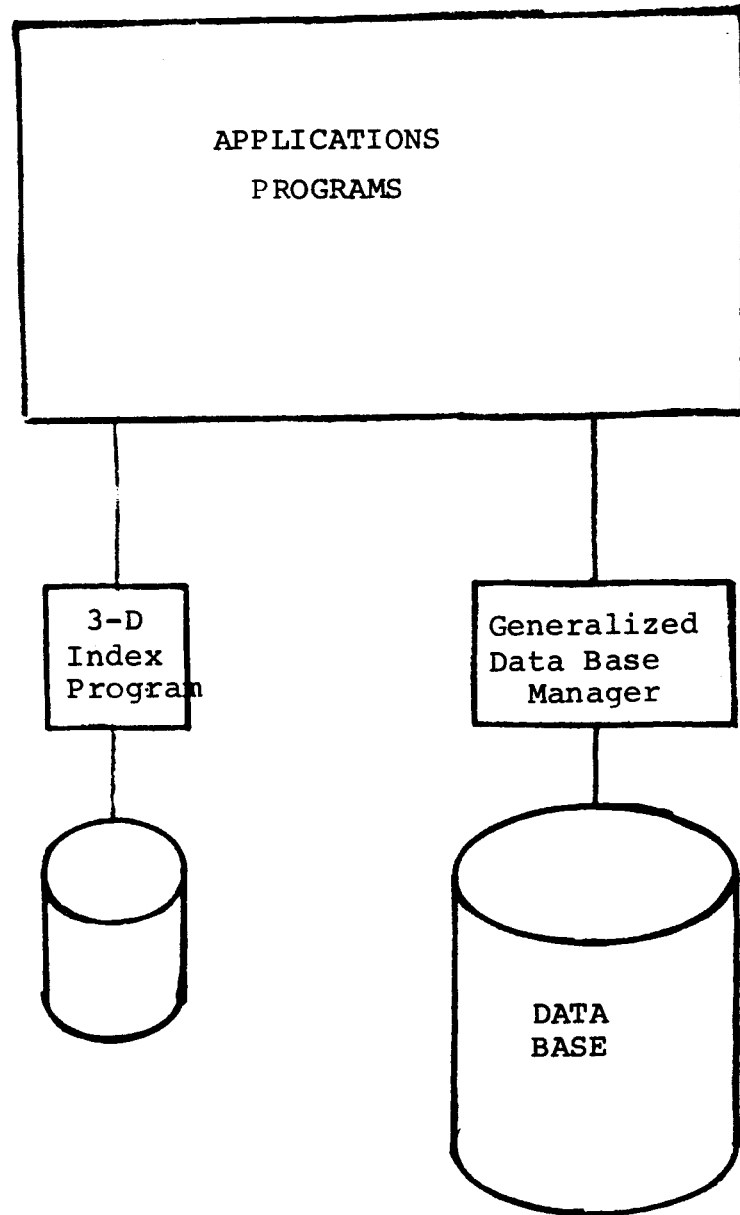
Figure 4.   Indexing the Generalized Data Base

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